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MICROWAVE RADIOTELEPHONE COMMUNICATION IN POLISH PORTS

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The reconstructed and rapidly expanding Polish ports on the Baltic are now making greater demands on the navigational and safety services such as the port Straz Pozarna (Fire Brigade) and the Sluzba Ratownicza (Rescue Service). Old communication equipment and old-fashioned methods of communication no longer meet the needs of modern ports. Fast, efficient, and dependable communication is a decisive factor in the safety of operations.

For the radiofication of the Straze Portowe (Port Guards) and the Kapitanaty Portow (Port Authorities), equipment was purchased from abroad, and on 26 July 1949, the first radio installations were put in service. Frequency modulated radio apparatus now being installed in Poland assure dependable and fast telephone connections in densely populated areas and over the broad expanses of the ports. The radio system provides two-way communications between a fixed governing station and one or more mobile units assembled on vehicles, etc. The equipment of either a fixed or mobile unit consists of a transmitter, receiver, feeder, control unit, microphone amplifier, loud-speaker, and antenna.

The system permits ordinary telephone conversation between the fixed governing station and mobile stations. The transmitter and antenna of the fixed station is located at some distance from the control point. The remote control is conducted over a four-strand telephone cable. The fixed station is equipped with two receivers and a transmitter with two quartz crystals. This gives two frequencies -- one for communications with mobile units, and one for communications with a similar fixed governing station of the port Straz Pozarna in an emergency.

Many considerations governed the selection of frequency band and power. It was necessary to insure good communications in a radius of 50 kilometers with minimum interference from coastal maritime radio communications and radiofication. Hence, a very high frequency (over 30 megacycles per second) was selected, beyond the range of bands used for other purposes. Frequency modulation was adopted on a large scale for the first time in Poland.

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The ionosphere does not reflect microwaves, thus their range is bounded by the horizon. Because waves are refracted in the atmosphere, the horizontal range of microwaves is actually somewhat greater. The dielectric constant of the earth's atmosphere is somewhat greater than unity. The dielectric constant of the atmosphere, and also the index of refraction of electromagnetic waves, is inversely proportioned to altitude; thus, because of the deflection of the waves from air with a lower dielectric constant to air with a higher constant, the range is somewhat increased. The effect is variable and depends on the humidity of the atmosphere.

Assuming that the height of a receiving antenna is negligible, the following formula may be used to define the operational range as a function of the transmitting antenna's height: $r_o = \sqrt{2h_1 R}$. The height of the antenna is h_1 and the radius of the earth, R. Correction for the earth's curvature is made by multiplying the earth's radius by 1.33 to obtain the effective earth radius. Thus, the corrected formula is $r_o = 4.13\sqrt{h_1}$. If h_1 is expressed in meters, r_o is expressed in kilometers. If the receiving antenna is also very high, as in the case of two fixed stations in contact with each other, the formula is $r_o = 4.13\ (\sqrt{h_1} + \sqrt{h_2})$. Since the range depends on the height of the antennas, these should be as high as possible.

In urban areas, the reflection of microwaves produces distortion. On the seacoast, where antennas are much higher than the surrounding buildings, this distortion is minor. In cities with high buildings, however, this phenomenon is of major importance. As a countermeasure, directional receiving antennas are used which pick up only direct waves and ignore reflected waves.

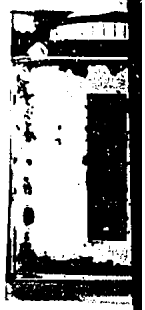
The first stage of a frequency modulation transmitter is the oscillator, with a crystal-controlled triode and the heptode part of the tube used as a limiter.

The reactance tube changes the current phase of high frequency into frequency modulation. Afterward, it is sufficient to multiply the frequency of the quartz crystal the proper number of times to obtain frequency modulation and maintain the stability of the carrier wave. If the reactance tube is used with a self-excited oscillator, then the tube's operation is more powerful and frequency modulation is obtained directly, but at the expense of the carrier wave's stability.

Multipliers amplify high frequencies with tuned circuits. If a high-frequency voltage is applied to the amplifier network, oscillations will be produced on the circuit which will be many times greater than the original oscillation, depending on the circuit tuning. The danger of exciting high frequency in the amplifier is very great; therefore, the multiplier is of great importance because it multiplies the frequency and reduces the possibility of a feedback.

The last stage of the transmitter is the final power amplifier operating on a tuned circuit. The modulator, activated by contact pressure in the microphone, switches the antenna from the transmitter into the receiver and vice versa in a two-way conversation.

The receiver, a superheterodyne type with frequency doubling, operates on 12 tubes. The first tube is the high-frequency amplifier. The second tube is the local oscillator, operating on the triode part of the tube, and controlled by the quartz crystal; the heptode part of the tube is the 4x multiplier. The third tube, operating as a mixer, gives an intermediate frequency of 6.15 megacycles per second. The fourth tube amplifies the intermediate frequency, and the fifth is the second mixer. The triode part, operating as an oscillator, and the heptode part, operating as a mixer, gives the second intermediate frequency of 1.48 megacycles per second. The seventh and the eighth tubes are intermediate



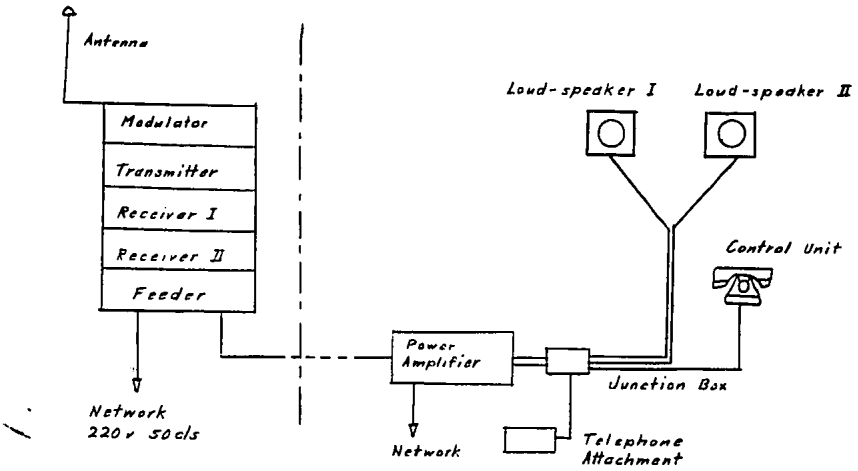
frequency amplifiers. The anode circuit of the eighth tube and the two diodes of the ninth tube constitute the discriminator, or the detector of modulated frequency voltage, changing it into audiofrequency. The detected voltage is amplified by the triode of the tenth tube and by the twelfth tube (output power tube), which feeds the receiver and the telephone earphones. The final intermediate frequency tube acts as a limiter which keeps the level of audio-frequency currents constant, from signals of one to 2 microvolts to the most powerful ones.

A mobile station obtains its power from a 12-volt battery, and the high voltage for the transmitter and receiver are produced by two converters. The fixed station obtains its power from a 220-volt alternating-current network, and the high voltage is produced by transformers and a group of rectifiers.

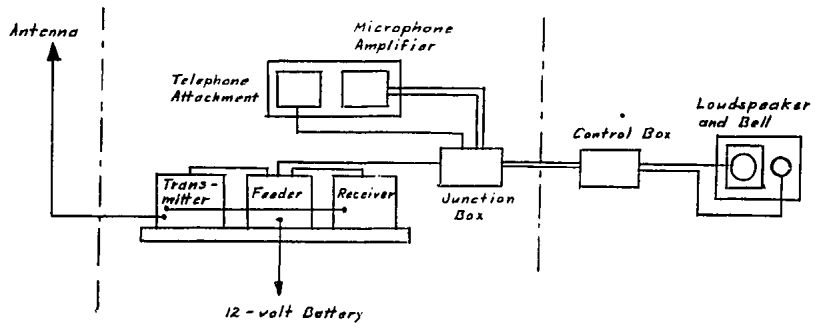
The fixed station is adjusted so that it can be controlled from the municipal telephone network, and the change-over from a telephone line to a transmitter is made on the control board of the Straz Pozarna.

The radio equipment was installed in a vehicle, a fireboat, and one fixed governing station, and, after tuning, tests were made on the operation and on the propagation of microwaves and their behavior under various conditions of terrain and atmosphere in the Polish ports on the Baltic. The first tests, made on the streets of a city, confirmed the fact that tall buildings and other objects did not produce the so-called ghosts and that they did not completely destroy the electromagnetic field. Instead, the intensity of the electromagnetic field was somewhat reduced, but good reception was obtained from all points of the city. In the tests for range, it was found that as the mobile unit receded in a straight line from the fixed station, constant contact was maintained right up to the limit of the range. Despite the relatively low antenna tower of the fixed station and the bad terrain conditions, such as hilly and forested areas, good results were obtained. The maximum range under such unfavorable conditions was about 20 kilometers. Thus, the first experiment with frequency modulation was successful, and the equipment was put in service to safeguard Polish ports.

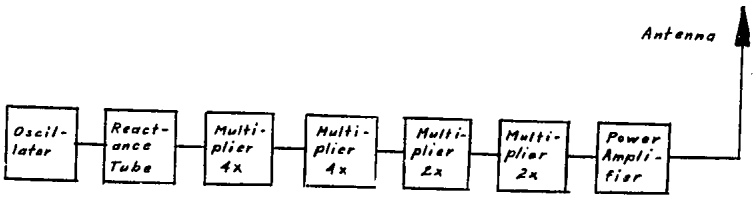
/Block diagrams of a frequency modulated fixed station, mobile station, transmitter, and receiver follow:/



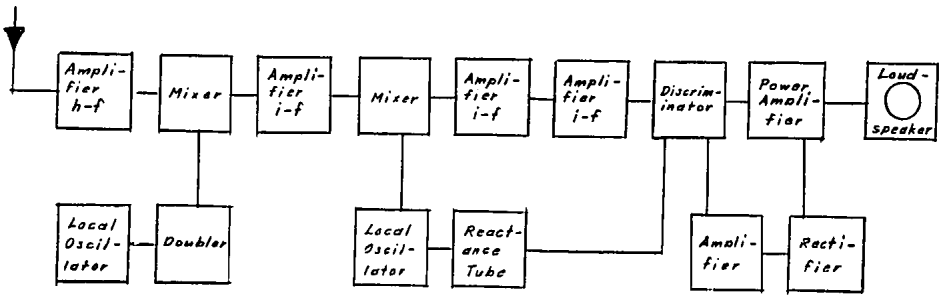
Block Diagram of Fixed Station



Block Diagram of Mobile Station



Block Diagram of Transmitter



Block Diagram of Receiver

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